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Physio-Morphological Traits and Yield Potentials of Chrysanthemum

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Abstract

A field study was conceded to assess the morphological and yield contributing characteristics of twenty-seven germplasm of chrysanthemum in Horticulture Research Centre (HRC), Gazipur, Bangladesh. The flower color in chrysanthemum were categorized into white, yellow, red, orange, pink, and intermediate colors, and the maximum flower period was observed in germplasms early December-February. The germplasms were observed 25.94% anemone, 3.70% pompon, 3.70% single, 22.22% incurved, 3.70% spider, 18.52% reflexed, 3.70% spoon and 18.52% intermediate type of inflorescence. The plant height, branch number, leaf number, leaf size, flower size and flower production of germplasms were varied from 35 to 75 cm, 4 to 8 plant^{-1}, 210 to 95 plant-1, 5.5 to 12.0 cm, 2.5 cm to 9.0 cm and 28.0 to 210 plant^{-1}. The longest 14 days and 12 days and shortly 5 days were observed in CM-009 and BARI chrysanthemum-2, CM-015, CM-022, CM-023, CM-024, and CM-025 and CM-008, respectively. The high genetic advance were (82.56 and 81.69%), (90.71 and 84.43%), (98.73 and 90.29%) and (93.94 and 92.61%) flower yield, number of flower/plant, flower size, stalk length and vase life of flower (83.66 and 86.50%). The high heritability along with the lowest estimates of genetic advance was found in plant height (80.37 and 35.10%).

Keywords: Morphology, yield, chrysanthemum and germplasm.

Introduction

Chrysanthemum (*Chrysanthemum indicum* L.) is a popular flower crop belongs to the family Compositae. It is commercial importance ornamental flower plant and one of the four most popular cut flowers in the world; therefore, this flower occupies a very important position in the world flower industry (Sun *et al*., 2011, Sun *et al.*, 2010, Sun *et al*., 2009, Anderson, 2007). It has been commonly grown in gardens for more than 2500 years (Singh, 1995). It is one of the most important ornamental crops around the world, and it is produced as both cut flower and pot plant (Van Der Ploeg and Heuvelink, 2006). It is a short-day plant with a critical day length of approximately 13.5 h (Post, 1931; Furuta, 1954). When natural night lengths are long (>12 h), photoperiod is shortened by extending a blackout material over the crop in order to promote flowering in short day (SD) crops (Runkle and Fisher, 2004). The wide variation exhibited by the large number of cultivars regarding growth habit, size, color, and shape of blooms makes them suitable for every purpose likely of a flower. The erect and tall-growing cultivars are suitable for background planting in borders or for use as cut flowers. The cultivars with the dwarf and compact growing habit, on the other hand, are suitable for front row plantation or pot culture. The decorative and fluffy bloomed cultivars are ideal for garland making and hair decoration. The extra-large bloomed cultivars are prized for their exhibition value. Understanding the nature and magnitude of variability among the genetic stocks is the prime importance to the breeder. Good knowledge of genetic wealth might help in identifying desirable genotype for commercial cultivation. The Floriculture Division of HRC, BARI, Gazipur, has a collection of 25 genotypes of Chrysanthemum with wide variabilities both in respect of plant and floral characteristics. Genetic and environmental factors control expression of different plant characters. It is often difficult to know the proportion factors of heritable and environmental variation.The progress of breeding conditioned by magnitude, nature and interaction of genotypic and environmental variations in the plant characters. So, the study of genetic parameters is necessary for breeding program. This will provide valuable information on mode of inheritance of different characters that would be useful in selecting plants with desirable characters to develop new varieties or promising genotypes. Good quality flower production depends upon various factors such as genotype, environment, spacing, disbudding, pinching, substrate, use of growth regulator etc. (Dutta and Ramadas, 2000). Moond and Rakesh, 2006). The full plant has health benefit but the famous part is the flower used in chrysanthemum tea (Jung 2009). It always used in traditional drug method for the treatment of numerous infectious diseases such as pneumonia, colitis, stomatitis, cancer, fever, sore and used to treat vertigo, pertussis and hypertensive symptom (Jung 2009). Active compounds in *C. indicum* are glycosides, adenine, and flavonoids. Previous research work also showed that *C. indicum* has the ability to act as antibiotic to many species of bacteria (Jung 2009). However, there was no information available on the effect of pinching, substrates and use of growth regulator on quality flower production of Chrysanthemum in Bangladesh. So, it is necessary to find optimum substrate, use of growth regulator and pinching time for better growth and yield. This study determined days to leaf color and size, flower color, size period and behavior, sucker number, number of flowers per plant.

Materials and Methods

The experiment was conceded out at the Landscape, Ornamental and Floriculture Division of Horticulture Research Centre (HRC), Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur, Bangladesh to investigate the physio-morphological and yield potentialities of chrysanthemum germplasm. Twenty-seven chrysanthemum germplasm with high ornamental values were used as materials in this study such as CM-001, CM-002, CM-003, CM-004, CM-005, CM-006, CM-007, CM-008, CM-009, CM-010, CM-011, CM-012, CM-013, CM-014, CM-015, CM-016, CM-017, CM-018, CM-019, CM-020, CM-021, CM-022, CM-023, CM-024, CM-025, CM-026 and CM-027. The experiment was conducted in earthen pots of 12 cm size. The pots were washed and cleaned thoroughly before filling up of potting media. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Heritability in broad sense (h2b) was estimated by the formula as suggested by Johnson *et al.*, (1995).

$$\text{Genotypic Variance } \sigma^2 g = \frac{MS_v - MS_e}{r}$$

Where, MS_V = Mean sum of squares for genotypes, MS_e = Mean sum of squares for error, r = Number of replications

Phenotypic variance ($\sigma^2 p$) = $\sigma^2 g + \sigma^2 e$

Where, $\sigma^2 g$ = Genotypic variance, $\sigma^2 e$ = Mean square for error

Table 1. Characteristics of chrysanthemum germplasm in respect of leave colour, flower colour and flowering period.

Germplasm	Leaf colour	Colour of flowers	Flowering period
CM -001	Green	Light pink	Mid December-Mid January
CM -002	Light green	Yellow	Early December-Early February
CM -003	Green	Light pink	Mid December-Late January
CM -004	Deep green	Red	Early December-Late January
CM -005	Green	Bronzy yellow	Early December-Late January
BARI Chry-1	Light green	Yellow	Early December-Late January
CM -007	Green	Light pink	Mid December-Mid January
CM -008	Green	Purple red	Mid December-Mid January
CM -009	Light green	Yellowish bronze	Late December-Late April
CM -010	Green	Orange yellow	Mid December-Early February
CM -011	Light green	Red	Mid December-Early February
CM -012	Green	Reddish yellow	Early December-Early February
CM -013	Light green	Orange	Mid December-Late January
BARI Chry-2	Light green	White	Early December-Early February
CM -015	Green	Majenta	Early December-Early February
CM -016	Green	Pinkish white	Mid December-Mid January
CM -017	Light green	Whitish yellow	Mid December-Late January
CM -018	Green	Deep pink	Mid December-Early February
CM -019	Deep green	Blackish red & pink	Early December-Early February
CM -020	Green	Light pink	Early December-Late January
CM -021	Light green	Light pink	Early December-Late January
CM -022	Deep green	Deep pink	Early December-Early February
CM -023	Deep green	Blackish red	Early December-Early February
CM -024	Green	Deep yellow	Early December-Early February
CM -025	Green	Red	Early December-Early February
CM -026	Light green	Light pink	Early December-Early February
CM -027	Light green	White	Early December-Early February

$$h^2_b(\%) = \frac{\sigma^2 g}{\sigma^2 p} \times 100$$

Where, σ^2_g = Genotypic variance, σ^2_p = Phenotypic variance

The expected genetic advance (GA) = $h^2_b . k . \sigma_p$

Where, h^2_b = Heritability in broad sense, k = Selection intensity which is equal to 2. 06 at 5%, σ_p = Phenotypic standard deviation

Genetic advance in percentage of mean was calculated by the formula given by Comstock and Robinson (1952) as follows:

$$GA(\%) = \frac{GA}{\overline{X}} \times 100$$

Where, GA = Genetic advance, $\overline{X}$ = Population mean

The collected data for various traits were statistically analyzed using MSTAT-C computer package program. The mean for all the treatments was calculated and the analysis of variance for each of the characters was performed by F (variance ratio) test. The differences between treatment means were separated by the Least Significant Difference Test according to Steel and Torrie (1960) for the interpretation of the results.

Results and Discussion

Color of leaf

The green color of leafs were observed in chrysanthemum of CM -001, CM -003, CM - 005, CM -007, CM -008, CM -010, CM -012, CM -015, CM -016, CM -018, CM -020, CM -024 and CM -025. The

Table 2. Plant and flower characteristics of chrysanthemum germplasm.

Germplasm	Plant height	Branch number	Leaf number	Leaf size	Flower size	Flower yield/plant
CM -001	46.00	5	145	8.0	4.5	57.6
CM -002	48.00	6	210	5.9	2.5	65.0
CM -003	45.00	4	130	5.5	4.2	28.0
CM -004	42.00	6	180	9.0	7.0	108.0
CM -005	35.00	6	137	6.5	4.5	72.2
BARI Chry-1	40.00	7	165	6.5	4.0	44.0
CM -007	55.00	5	150	8.5	6.8	93.6
CM -008	45.00	5	110	6.5	5.7	71.5
CM -009	58.00	6	170	8.0	5.0	133.5
CM -010	50.00	5	140	7.4	4.8	33.8
CM -011	49.00	5	157	7.3	4.4	40.0
CM -012	39.00	6	200	5.8	2.6	68.6
CM -013	61.00	5	135	7.0	7.8	110.0
BARI Chry-2	40.00	6	175	7.5	7.0	270.0
CM -015	45.00	7	195	7.3	7.0	270.0
CM -016	50.00	5	110	7.0	5.1	40.0
CM -017	56.00	4	95	12.0	7.2	100.0
CM -018	51.66	8	195	6.8	4.5	104.0
CM -019	40.00	7	120	6.0	2.8	70.4
CM -020	50.00	6	130	6.9	4.2	57.0
CM -021	40.00	5	150	6.4	2.5	78.4
CM -022	60.00	6	200	7.4	7.5	121.0
CM -023	58.00	7	190	7.6	9.0	125.0
CM -024	48.00	7	205	7.3	6.5	120.0
CM -025	64.00	7	200	7.5	7.3	126.0
CM -026	75.00	5	120	10.8	7.4	90.0
CM -027	55.00	5	125	10.5	5.0	86.7
LSD (0.05)	6.35	3.23	5.60	4.11	6.62	5.69
CV (%)	20.87	20.50	21.71	22.14	20.44	24.18

light green color of leafs were noted in chrysanthemum CM -002, BARI Chry-1, CM -009, CM -011, CM -013, BARI Chry-2, CM -017, CM -021, CM -026 and CM -027. The deep green color of leafs were recorded in chrysanthemum CM -004, CM -019, CM -022 and CM -023 (Table 1). The similar results were founded different color of leaf in chrysanthemum cultivars (Taweesak *et al.*, 2014).

Color of flower

Wide range of variations was observed in respect of color. The different germplasms showed attractive color of flowers (Table 1). The white color of flowers was observed in chrysanthemum of BARI Chry-2 and CM -027. The yellow flowers were recorded in chrysanthemum of CM -002 and BARI Chry-1. The red flowers were recorded in chrysanthemum of CM –004, CM -011 and CM -025. The chrysanthemum of CM -013 was noted in orange color flower.

Figure 1. Flower variability in chrysanthemum germplasm.

Table 3. Phenotypic and genotypic co-efficient of variation, heritability, genetic advance for different characters in chrysanthemum germplasm.

Characters	Genotypic co-efficient of variation	Phenotypic co-efficient of variation	Heritability	Genetic advance (1% of mean)
Plant height (cm)	26.52	27.69	80.37	35.10
No. of leaves	19.77	26.03	53.48	29.78
Plant spread (cm)	15.67	21.63	57.99	44.65
No. of sucker plant^{-1}	29.93	30.63	64.58	63.21
No. of flower plant^{-1}	29.01	30.77	90.71	84.43
Flower size (cm)	19.87	20.38	98.73	90.29
Stalk length (cm)	46.29	47.86	93.94	92.61
Vase life (days)	25.01	26.20	83.66	86.50
Days to flowering	4.85	9.45	62.96	59.74
Flower yield (gm)	13.81	14.99	82.56	81.69

The chrysanthemum of CM -001, CM -003, CM -007, CM -020, CM -021 and CM -026 were showed in light pink color flowers. The rest chrysanthemum flowers were observed as intermediate colors (Figure 1). The different variations of flower in chrysanthemum (Taweesak *et al.,* 2014) was showed different color.

Flowering period

Flowering periods of different germplasms were recorded and presented in Table 1. The different germplasms gave flowering with varying times in a year. The mid December-mid January flowering period was recorded in chrysanthemum of CM -001, CM -007, CM -008 and CM -016. The early December-early February flowering period was noted in chrysanthemum of CM -002, CM -012, BARI Chry-2, CM -015, CM -019, CM -022, CM -023, CM -024, CM -025, CM -026 and CM -027. The mid December-late January flowering period was noted in chrysanthemum of CM -003, CM -013 and CM -017. The early December-late January flowering period was noted in chrysanthemum of CM - 004, CM -005, BARI Chry-1, CM -020 and CM -021. The late December-late April flowering period was only noted in chrysanthemum of CM-009. The mid December-early February flowering period was only noted in chrysanthemum of CM -010, CM - 011 and CM -018 (Table 1 and Figure 1). Slightly similar results were noted by (Hanke, 1996) and (Dutta and Ramadas, 2000). Days to flower can be scheduled by manipulating the day length in photoperiodic crops like chrysanthemum, the year-round production of which can be achieved.

Inflorescence type

The different germplasms showed a wide variation in type of inflorescence (Figure 2). The type of inflorescence was graded into anemone, pompon, single, incurved, spider, spoon, reflexed and intermediate. Among the germplasms, 25.94% anemone, 3.70% pompon, 3.70% single, 22.22% incurved, 3.70% spider, 18.52% reflexed, 3.70% spoon and 18.52% intermediate type of inflorescence. (Wang *et al.,* 2014) was reported about inflorescence type of chrysanthemum.

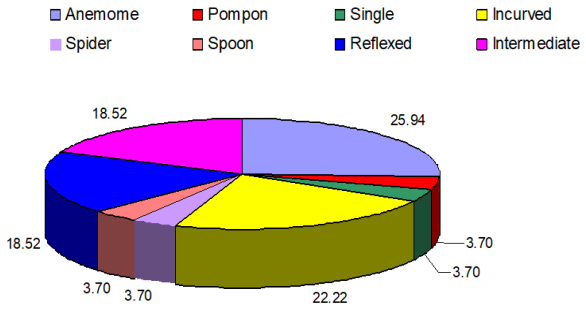

Figure 2. Variability in Inflorescence type.

Plant height

Analysis of variances revealed marked differences among the genotypes in respect of plant height. It varied from 35 to 75 cm where the tallest plant was produced by the germplasm CM-026, while the shortest plant was recorded in germplasm CM-05 (Table 2). The co-efficient of variation (CV) was moderately high (20.87) for this trait indicating the presence of variability among the genotypes. (Tewari and Shankar,1994) conducted a performance trial of

Table 4. Genotypic (g) and phenotypic (p) correlations among ten characters in 27 chrysanthemum germplasm

Traits	Corre. coefficient	No. of leaves /plant	Plant spread	No. of sucker / plant	No. of flower/ plant	Flower size	Stalk length	Vase life	Days to flower	Stalk length
Plant height	r_g	-0.372	0.014	-0.120	-0.220	-0.196	-0.425*	-0.45*	0.742**	-0.244
	r_p	-0.291	-0.015	-0.072	-0.052	-0.175	-0.409*	-0.389*	0.637	-0.231
No. of leaves	r_g		0.174	0.484**	0.409*	0.623**	0.335	0.504**	-0.304	0.271
	r_p		0.113	0.350	0.072	0.988**	0.198	0.074	-0.225	0.235
Plant spread	r_g			0.830**	0.674**	0.725**	0.596**	0.877**	-0.74**	0.764**
	r_p			0.578**	0.408 *	0.465*	0.464*	0.574**	-0.366	0.598**
No. of sucker/ plant	r_g				0.652**	0.566**	0.540**	0.625**	-0.46**	0.514**
	r_p				0.441*	0.385*	0.498**	0.487**	-0.284	0.436*
No. of flower/ plant	r_g					0.856**	0.540**	0.540**	-0.75**	0.494**
	r_p					0.655**	0.350	0.481*	-0.19**	0.325
Flower size	r_g						0.435*	0.656**	-0.83**	0.495**
	r_p						0.375*	0.525**	-0.46**	0.389*
Stalk length	r_g							0.269**	-0.918*	0.663**
	r_p							0.254**	-0.534*	0.591**
Vase life	r_g								-0.94**	0.746**
	r_p								0.438	0.540**
Days to flower	r_g									-0.98**
	r_p									0.525**

* and ** Significant at 5% and 1% levels respectively; rg and r_p indicate genotypic and phenotypic correlation respectively.

chrysanthemum cultivars and reported that plant height ranged from 38 -77 cm which was not at par with the present investigation. The variation observed here might be due to difference in genetic constituents among the germplasms along with environmental effects.

Number of leaves

Significant variation was observed as to the number of leaves among the germplasms (Table 2). The maximum number of leaves (210) was obtained from the germplasm CM- closely followed by germplasm CM-024 (205), CM-012(200), CM-022(200) and CM-(200) whereas germplasm CM-017 attained minimum number of leaves (95). This variation might be due to genotypic variation as well as environmental effects. Plants produce food materials through the process of photosynthesis. With the increasing number of leaves, photosynthesis will generally increase. Thus plant can produce more plant food that influences the growth and development of the plant. So, genotypes that can produce more leaves have more plant growth leading to higher yield. This result was noted with other findings that found that increased substrate volume led to increased leaf area of chrysanthemum (Goto *et al.*, 2001) and marigold (Latimer, 1991).

Figure 3. plant speed of chrysanthemum germplasm.

Number of branches

Variation regarding number of branch per plant among the germplasm was observed and varied from 5 to 8 (Table 2). The highest number of branch per plant was produced by CM-018 (8). The germplasm CM-003 and CM-017 produced the lowest number of branch per plant (4). The number of branch per plant varied from 4-10 as reported by (Parthasarathy and

Table 5. Path co-efficients of different yield contributing characters on flower yield of chrysanthemum germplasm

Characters	Plant height (cm)	No. of leaves plant^{-1}	Plant spread (cm)	No. of sucker plant $^{-1}$	No. of flower plant $^{-1}$	Flower size (cm)	Stalk length (cm)	Vase life (days)	Days to flower	Flower yield (Correlation)
Plant height (cm)	0.06	-0.02	-0.008	-0.15	0.04	0.07	0.4	0.004	0.001	-0.244
No. of leaves plant^{-1}	0.02	0.08	0.38	0.12	0.74	0.11	0.26	0.006	-0.008	0.271
Plant spread (cm)	-.006	0.30	0.84	-0.33	-0.36	0.08	0.25	-0.003	0.0010	0.764
No. of sucker plant $^{-1}$	0.014	-0.01	0.40	0.74	-0.36	0.09	0.37	0.006	0.007	0.514
No. of flower plant^{-1}	-0.003	0.08	0.44	-0.35	0.70	-0.08	0.24	-0.002	-0.003	0.494
Flower size (cm)	0.02	0.04	0.32	-0.29	0.26	0.50	-0.35	0.004	-0.004	0.495
Stalk length(cm)	0.04	0.03	0.32	-0.39	-0.26	-0.12	0.69	0.005	0.008	0.663
Vase life (day)	-0.002	0.05	-0.34	-0.55	0.16	0.09	0.41	0.801	0.75	0.746
Days to flower	0.005	-0.03	0.07	-0.26	0.13	-0.05	0.3	0.34	-0.070	0.987

Bold figures indicate direct effect Residual effect ® = 0.35

Shah, 1984) from their experiment on chrysanthemum evaluation in India.

Flower size

It was revealed that flower size varied significantly and ranged from 2.5 cm to 9.0 cm. The germplasm CM-023 showed the highest flower size (9.00 cm) followed by germplasm CM-017(7.80 cm), CM-022(7.50 cm) and CM-023 (7.30 cm). The lowest flower size (2.50 cm) was observed in germplasm CM-002 and CM-021 (Table 2). Misra (1999) found flower diameter varied from 2.30 – 10.00 cm which was at par with the present investigation and also mentioned this difference due to inherent genetic factors.

Leaf size

As regards leaf size ranged from 5.5 to 12.0 cm with the mean value of 8.75 among the observed germplasm, the largest size of leaf per plant was obtained from germplasm CM-017 (12.0 cm) while the smallest leaf (5.5) were recorded from the germplasm CM-002 (Table 2).

Flower yield

Data recorded in respect of flower yield in twenty-seven germplasm of chrysanthemum are presented in Table 2. The variety BARI chrysanthemum-2 and CM-015 produced the maximum flower yield per plant (270 g). The minimum flower yield per plant (28g) was recorded in CM-003. The same result was also observed by (Tewari and Shankar, 1994).

Vase life

A great deal of genotypic variation was observed in case of vase life (Figure 3). Among the, germplasm, CM-009 and BARI chrysanthemum-2 exhibited the longest vase life of days closely followed by CM-015, CM-022, CM-023, CM-024, and CM-025 with 12 days of duration. The shortest vase life duration (5 days) was exhibited by germplasm CM-008. Vase life of chrysanthemums like the study identical to the (Kazaz *et al.*, 2010).

Estimation of genetic parameters in chrysanthemum genotypes

The co-efficient of phenotypic and genotype variations, heritability estimates and expected genetic advance in percent of mean (1%) are shown in Table 3. Estimates of genetic parameters for each character are important for getting idea about their mode of inheritance. Such idea usually helps toward efficient selection. In the present study, a narrow difference between phenotypic and genotype co-efficient of variation was noticed for flower number, stalk length, flower size, sucker number and vase life,

indicating less environmental interference on the expression of these characters. Similar observations were made by (Nanjan 1994) in gerbera. A character can be improved only if it is highly heritable. The magnitude of h2 indicates the effectiveness with which the selection of genotypes can be made based on phenotypic performance (Johnson *et al.,* 1995). Out of 10 quantitative characters studied, stalk length, flower number, vase life, stalk length, flower size and plant height exhibited high heritability. The results were in consonance with the findings of (Sujatha 2002) in gerbera.

Even though the h_2 values give indication of effectiveness of selection based on the phenotypic performance, it does not necessarily mean a high genetic advance for a particular character. Heritability along with estimates of expected genetic advance should be considered while making selection. In crop improvement only the genetic component of variation is important since only this component of h_2 serve as a useful guide to the breeder.

If the h_2 of a character is high (0.8 or more), selection of that character is very effective. This is because there would be close correspondence between genotype and phenotypic variances due to relatively smaller contribution of environment to phenotype. But for character with low h_2 (less than 0.4), selection may be ineffective or virtually impractical due to masking effect of environment on genotypic effects. The characters exhibiting high h_2 with high genetic advance (Table 3) in this study were flower yield (82.56 and 81.69%), number of flower/plant (90.71 and 84.43%), flower size (98.73 and 90.29%), stalk length (93.94 and 92.61%) and vase life of flower (83.66 and 86.50%). This indicated additive gene action, suggesting the possibility of improvement of these traits through selection. Similar observations were reported by (Bhattacharjee. 1981) in gerbera. The characters exhibited moderate heritability along with moderate genetic advance were observed in number of sucker (64.58 and 63.21%) and days to flowering (62.96 and 59.74%) thus indicated moderate scope for improvement by selection for those character. The moderate heritability with the lowest genetic advance was observed in number of leaves (53.48 and 29.78%) thus indicated less scope for improvement by selection for this character. The high heritability along with the lowest estimates of genetic advance was found in plant height (80.37 and 35.10%) which might be due to non-additive gene effects for the particular character and would offer less scope for selection; because that was under the influence of environment.

Correlation Coefficient

The results showed that flower yield was positively correlated with the number of leaves plant^{-1}, plant spread, number of sucker plant^{-1}, number of flower plant^{-1}, stalk length, and vase life both at genotypic and phenotypic levels (Table 4). Among them, plant spread, stalk length and vase life were correlated positively and significantly with flower yield. Bose et al. (2003) reported flower yield was significantly and positively associated with plant spread, vase life and flower number in China aster which is agreeable with the present investigation results.

The genotypic correlations for days to flower with flower yield were negative but its corresponding phenotypic correlations were positive. So, it was indicated that this was due to the influence of environmental correlations among these traits for getting positive phenotypic correlations. It was observed that plant spread had the highest positive significant effect with flower yield both in genotypic and phenotypic level. Number of flower plant^{-1} was positively and significantly associated with flower size. Plant spread had significant positive correlations with number of sucker plant^{-1} and number of flowers plant^{-1} with flower size. So, plant spread would increase by the increasing number of suckers plant^{-1}.

Therefore, the correlations study among different characters suggested that number of flower plant^{-1}, stalk length, vase life, number of sucker plant^{-1} and flower size were the most important traits, which possessed significant positive association with flower yield. Therefore, selection for chrysanthemum genotypes having long stalk length, vase life, number of suckers plant^{-1}, number of flowers plant^{-1} and flower size will provide crop improvement towards in positive direction.

Path coefficient

Estimates of direct and indirect effect of nine yield contributing characters are shown in Table 5. From this analysis, it was observed that plant spread had maximum direct positive effect on flower yield. The genotypic correlation of plant spread with flower yield was also high. Such high correlation with flower yield was mainly due to the high positive direct effect of plant spread and considerable positive indirect effects via number of leaves plant^{-1}, flower size, number of stalk length and days to flower. The other traits like

flower number, number of sucker plant^{-1} and vase life had also high positive direct effects on flower yield. These direct effects were the principal components of their relationships with flower yield. Anuradha and Gowda (2000) studied on gerbera where the greatest positive direct effect was leaves plant^{-1} on flower yield. So, the results of the present study disagree with their finding. Mahanta *et al.,* (1998) reported that plant spread, flower size, flower number, stalk length and days to flower initiation had high direct effects. So, these findings partially support the present results.

Conclusions

From the study, it is evident that the genotypic correlations for days to flower with flower yield were negative but its corresponding phenotypic correlations were positive. It was observed that plant spread had the highest positive significant effect with flower yield both in genotypic and phenotypic level. Number of flower plant-1 was positively and significantly associated with flower size.

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Conflict of interest

Authors have declared that no competing interests exist.

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